IEE International Frequency Control Symposium 1998

Commercial Off-The-Shelf (COTS)

A Study of Plastic Encapsulated Microcircuits (PEMs) in JPL Space Hardware

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Electronic Parts Engineering Office

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Agenda

- Introduction to COTS
- COTS Work Plan/Status
- COTS Work for Plastic Packages
- Summary

The Meaning of COTS

- "Buy and Fly"
- "Procuring via catalog part number to QML-V standards"
- "Procurement is performed without formal specification"
- "The usage of any COTS equipment does not constitute any waiver to fundamental applicable requirements"

Our Interpretation:

COTS are parts whose specification is ***manufacturer -controlled*** as opposed to traditional "Hi-Rel"parts whose specification was ***Government or customer-controlled***

Why Put COTS in Space ?

1. The availability of COTS parts is proliferating.

2. COTS parts performance capabilities continue to increase (e.g. processing power & high density memories)

3. A new generation of leading COTS IC technologies is introduced every 3 years.

4. COTS parts typically cost much less than radiation hardened counterparts; by using radiation tolerant parts the cost advantage can be preserved.

5. Some COTS parts (plastic) have been reported to demonstrate good to excellent reliability.

JPL’s Concerns About Using COTS

- Reliability/RH of PEMS vs Traditional Ceramic
- Non Rad Hard Designed (maybe Rad Tolerant)
- Narrow Temperature Range
- Process/Designs Change Frequently

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Examples of Risk Indicators & Their Relative Costs for a Plastic Package:

• Temperature Humidity	→	Corrosion	($)
• Temperature Cycling	→	Assembly Defects	($)
• Moisture Absorption	→	Popcorning	($$)
• Radiation	→	TID Degradation	($$$$)
• Outgassing	→	Condensables	($$)
• Glass Transition	→	Stability	($$)

Work Conducted at JPL:

COTS Work- Plan/Status

Known Good Die	Plastic Packages	Part Family Evaluations	LPSEP
Vendor Surveys	Moisture Absorption	Flash Memory	Characterization
Vendor Screens	Outgassing	A/D & D/A	Reliability
User Risk	Radiation	Logic	Radiation
	Delamination	Others	

Completed
Planning
In Progress

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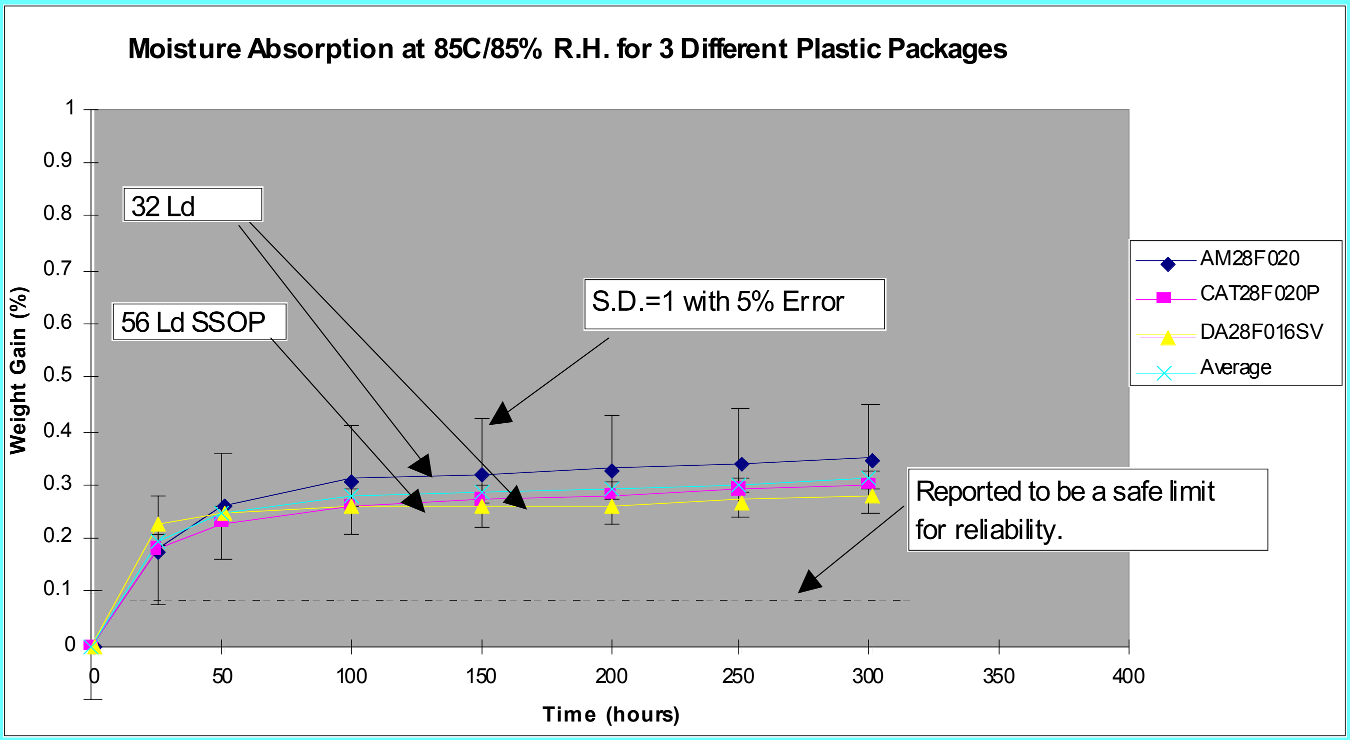
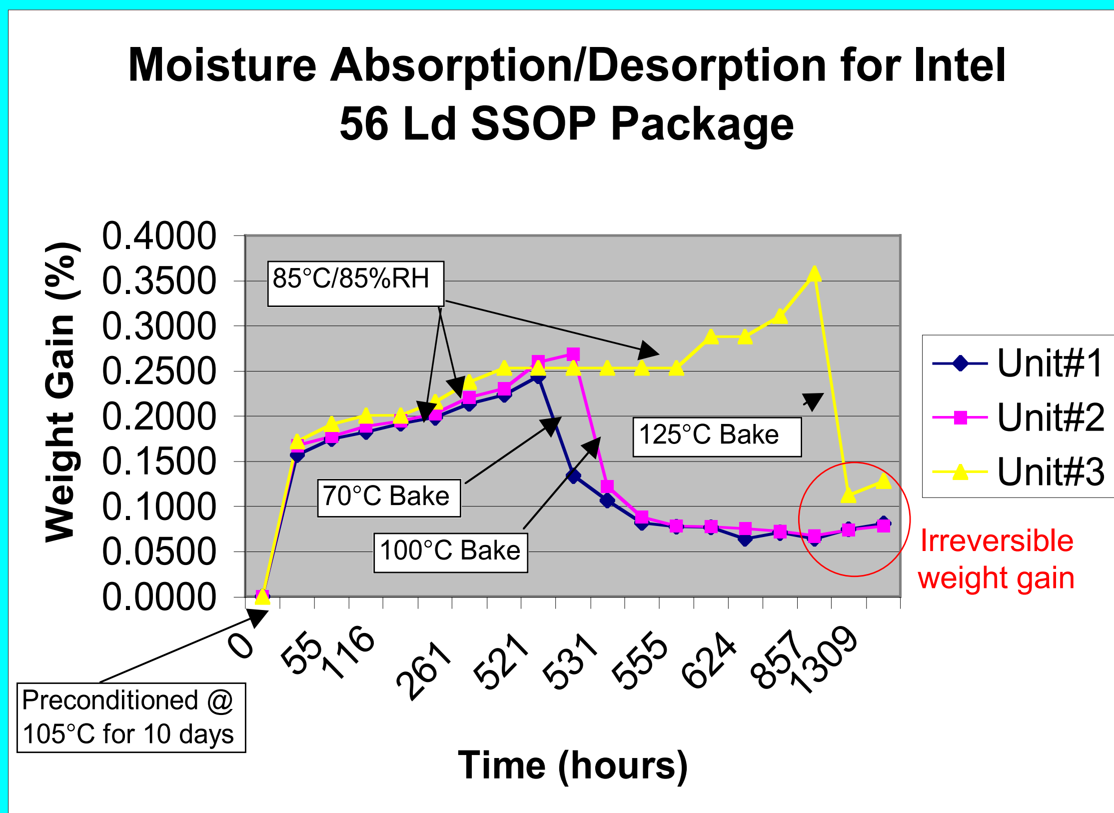


Conclusion: Most if not all plastic parts will absorb moisture >> 0.1% weight gain.



Note: Weight Gain (%) = (Wt-Wi)/Wi*100
Weight Loss (%) = (Wtd-Wi)/(Wf-Wi)*100

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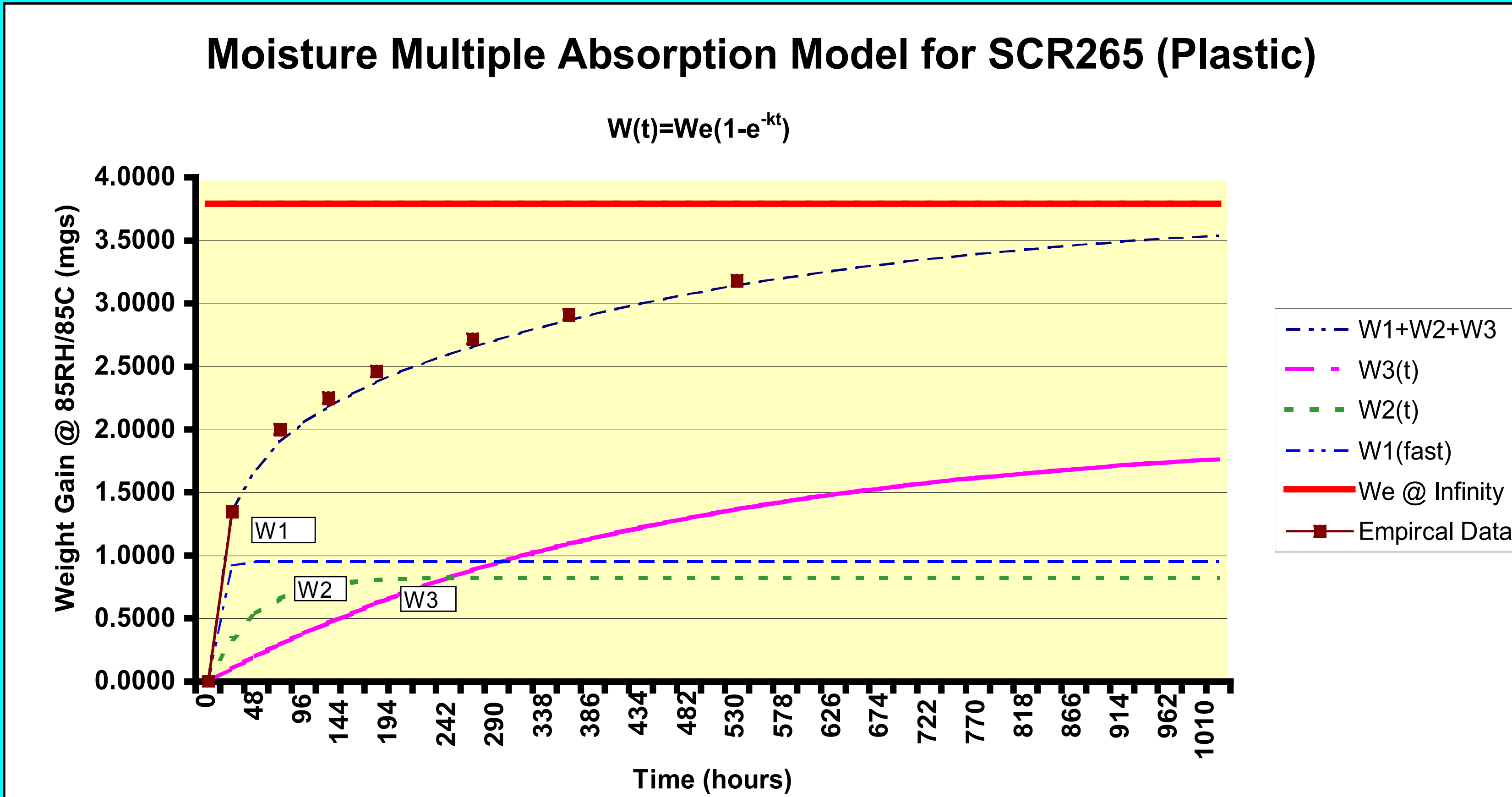
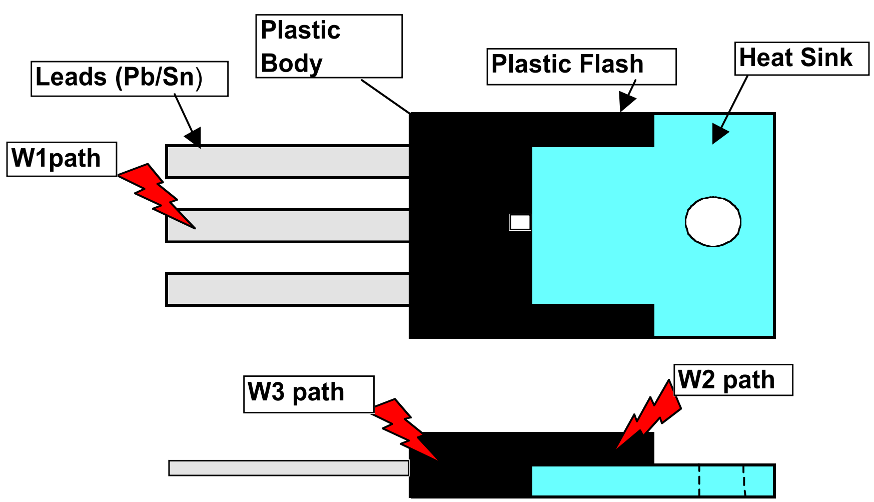


85%RH/85ºC Moisture Absorption Mechanisms for SCR265

- **W1(t):** Fast Irreversible Weight Gain ≤ 24 hours (~1mg)
- **W2(t):** Intermediate Reversible Weight Gain, 80 to 140 hours
- **W3(t):** Slowest Reversible Weight Gain, Reaches We @ t=∞

SCR265 Package



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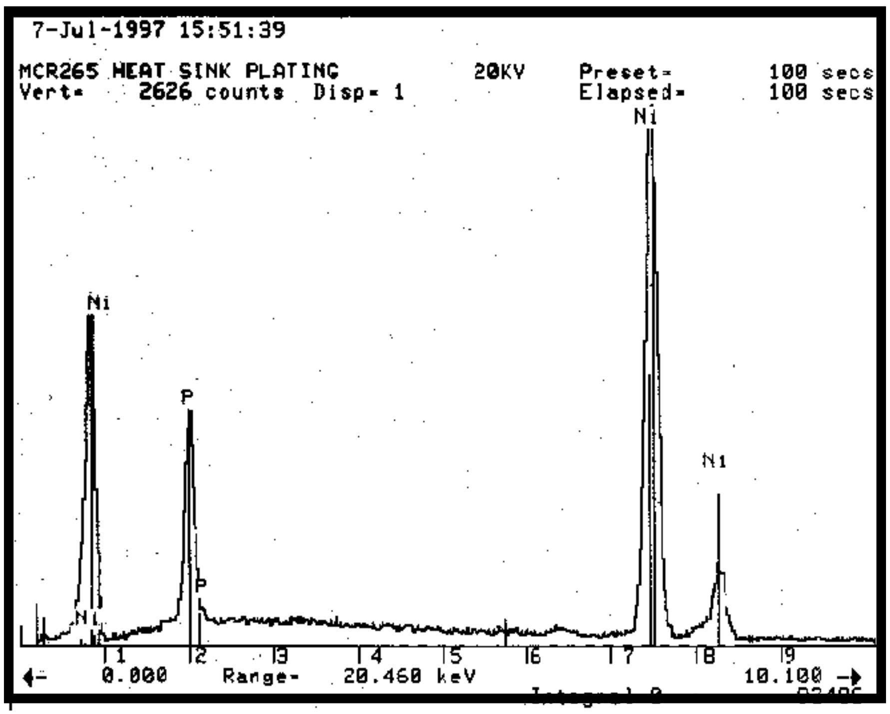
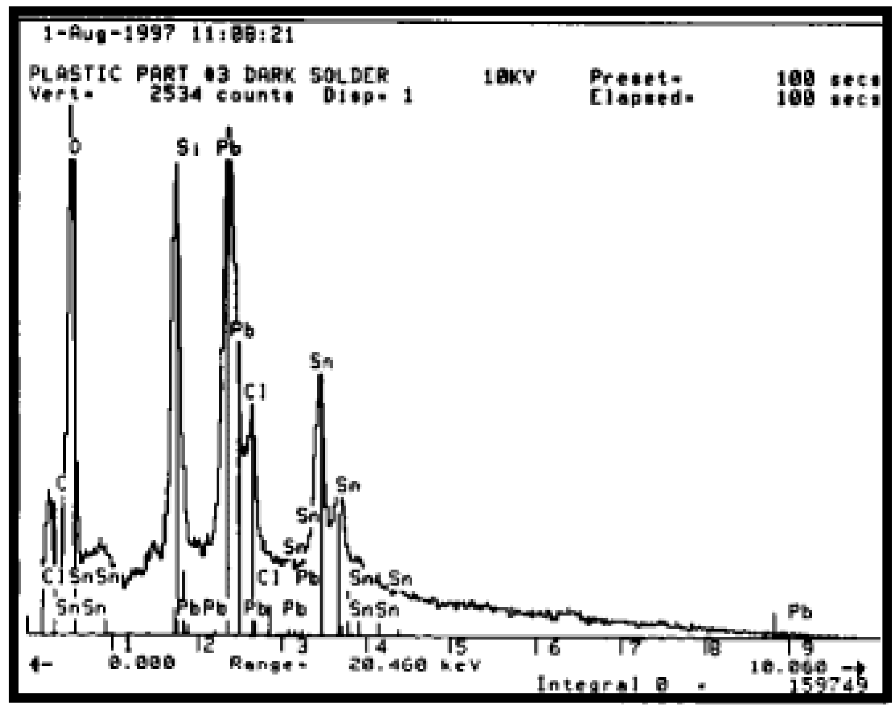
Nickel Plated Heatsink Shows No Oxidation

Post 85%RH/85ºC for SCR265

Leads Show Extreme Oxidation

➡ W1(t)





Conclusion: Weight gain is solely attributed to oxidation of leads. The internal chip has miniscule Al area available for oxidation because of Cu intermetallic bonding to the Al.

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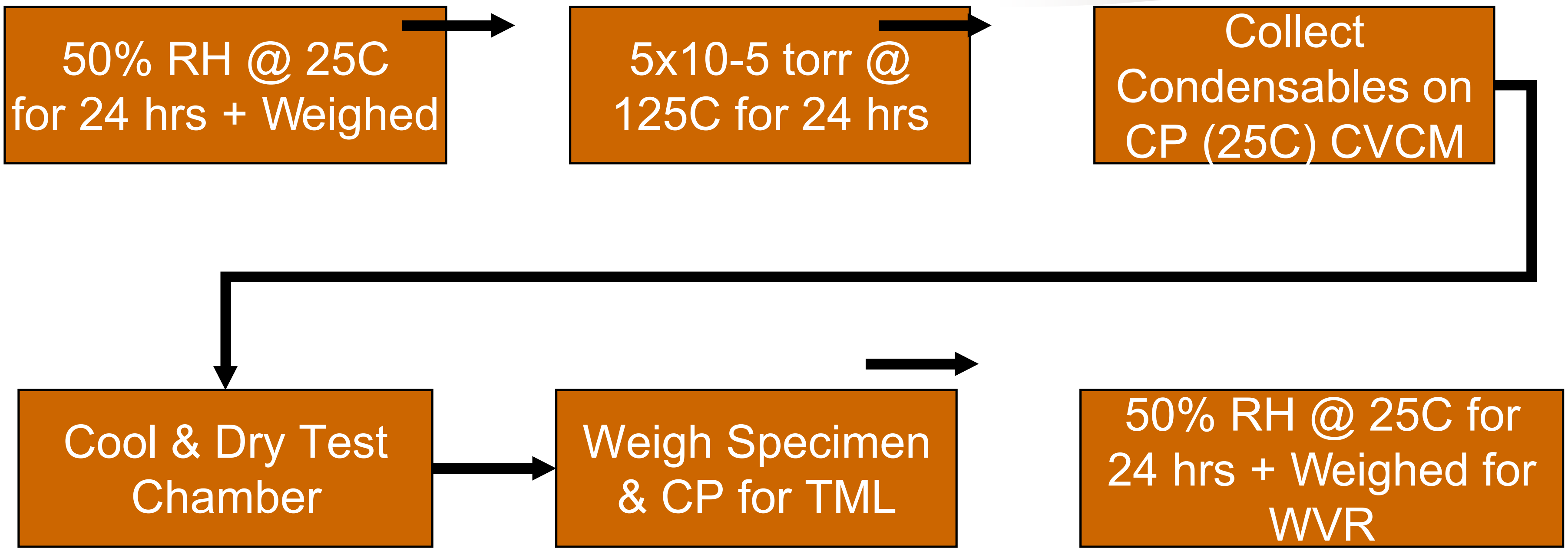
Outgassing Test Flow



Ref: ASTM E595-93

Outgassing Results of Plastic Packages

Material	MCR			7612382FBA, E24, DA28F016SV, K8055, U6240332			AM28F020-150PC, 9618FBB			CSI, CAT28F020F, 1-15 09550B		
Part	Motorola SCR			Intel 16 M Flash Memory			AMD 2M Flash Memory			Catalyst 2M Flash Memory		
Sample No.	5	6		7	8	a	9	10		11	24	
WT. Loss %	0.45	0.46	0.45	0.23	0.22	0.22	0.41	0.45	0.43	0.40	0.41	0.40
Water Vapor Recovered, WVR, %	0.28	0.25	0.26	0.14	0.11	0.12	0.19	0.17	0.18	0.21	0.18	0.19
TML (WT, LOSS-WVR) %	0.17	0.21	0.19	0.09	0.11	0.10	0.22	0.28	0.25	0.19	0.23	0.21
CVCM %	0.04	0.08	0.06	0.02	0.01	0.01	0.03	0.05	0.04	0.04	0.04	0.04
DEPOSIT on CP	Opaque			Negligible			Opaque			Opaque		
FTIR Results	Amine cured epoxy			Anhydride cured epoxy			Amine cured epoxy			Amine cured epoxy		

Conclusion: All materials passed. These tests are suited for lot-to-lot comparisons, tracking manufacturing continuity/changes, and measuring absorbed moisture at a known environment.

Radiation of Plastic Parts

Moisture Absorption / Bake for Intel DA28F016SV in Plastic Package

(0.6 µm ETOX IV Process Technology)

Conditions: Test Temperature = 25°C, Vdd = 5.0V, Vpp = 5.0V

Dose rate = 25r/s

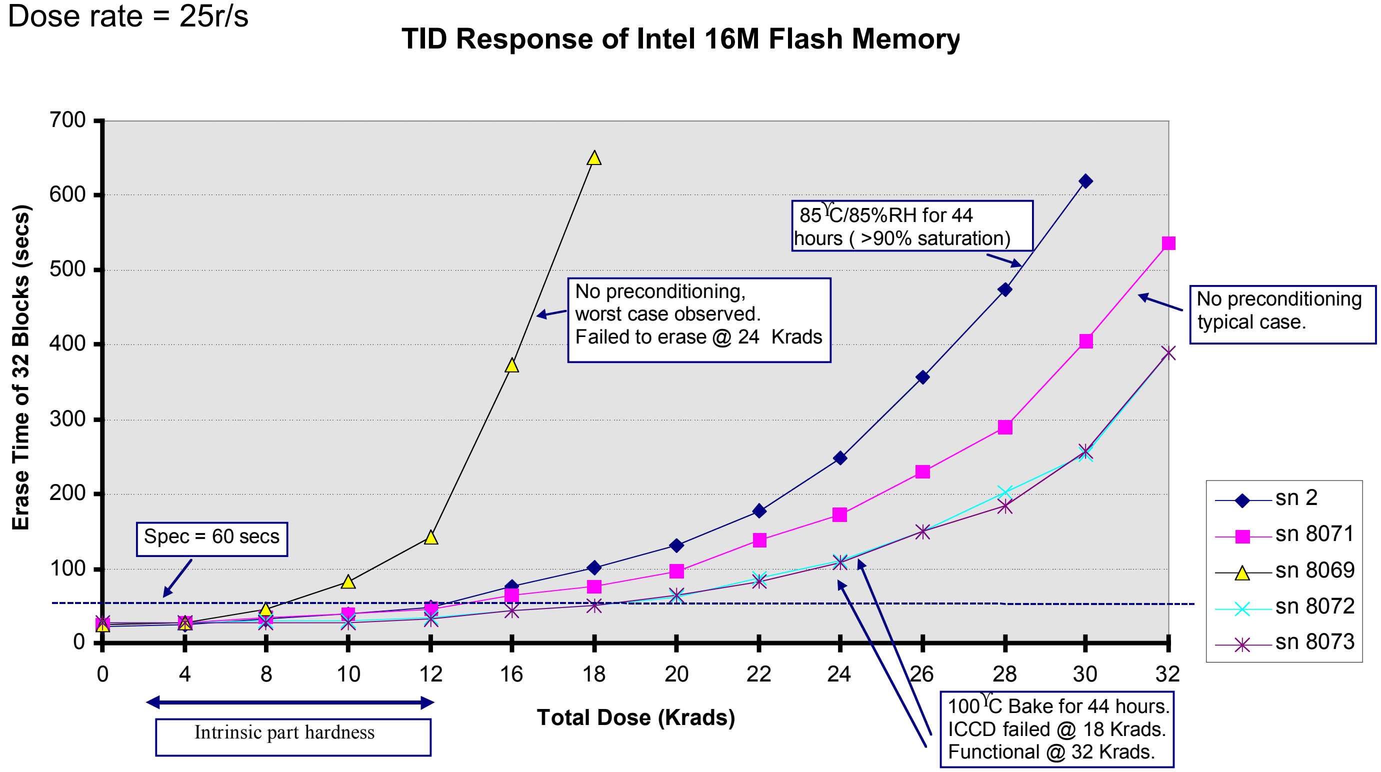


Figure 1
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In Summary

- Using plastic parts without understanding their pedigree can lead to mission delay or worst → **Mission Failure**

- A methodology is in place in Office 507 to help JPL users of plastic parts ascertain their risk and acceptance for Space Application

- Work is underway in Office 507 to evaluate **all risk factors** using COTS parts (quality, reliability, radiation, package, and device performance)

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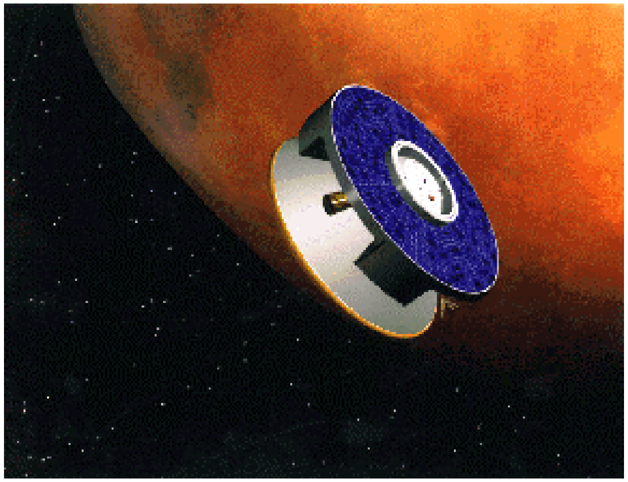
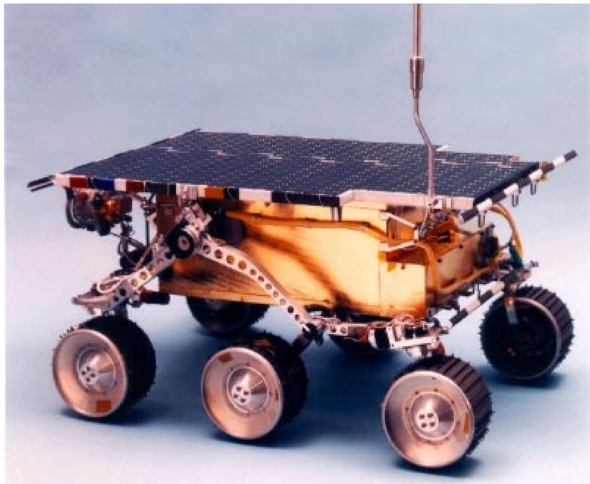
Plastic Parts Successfully Used For Mars Pathfinder:

16 Mbit DRAM Used in Pathfinder Flight Computer

FETs ; ASIC & Microcontroller Used in Modem for Lander and Rover





Passed 1000 Hours Life Test <u>on</u> <u>Mars</u> !